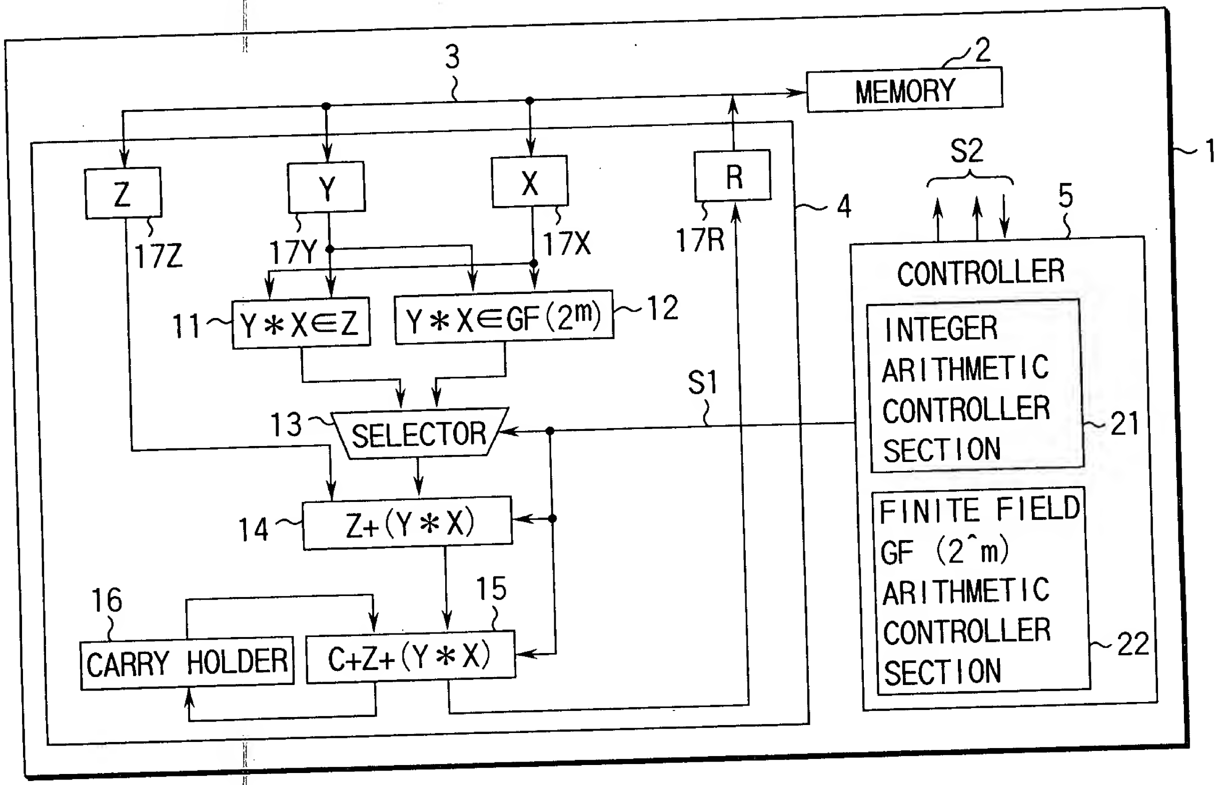

3
MEMORY
2
1
S2
5
Z
Y
X
R
4
17Z
17Y
17X
17R
CONTROLLER
INTEGER ARITHMETIC CONTROLLER SECTION
21
11
Y∗X∈Z
Y∗X∈GF(2m)
12
S1
13
SELECTOR
14
Z+(Y∗X)
FINITE FIELD GF (2^m) ARITHMETIC CONTROLLER SECTION
22
16
15
CARRY HOLDER
C+Z+(Y∗X)

FIG. 1

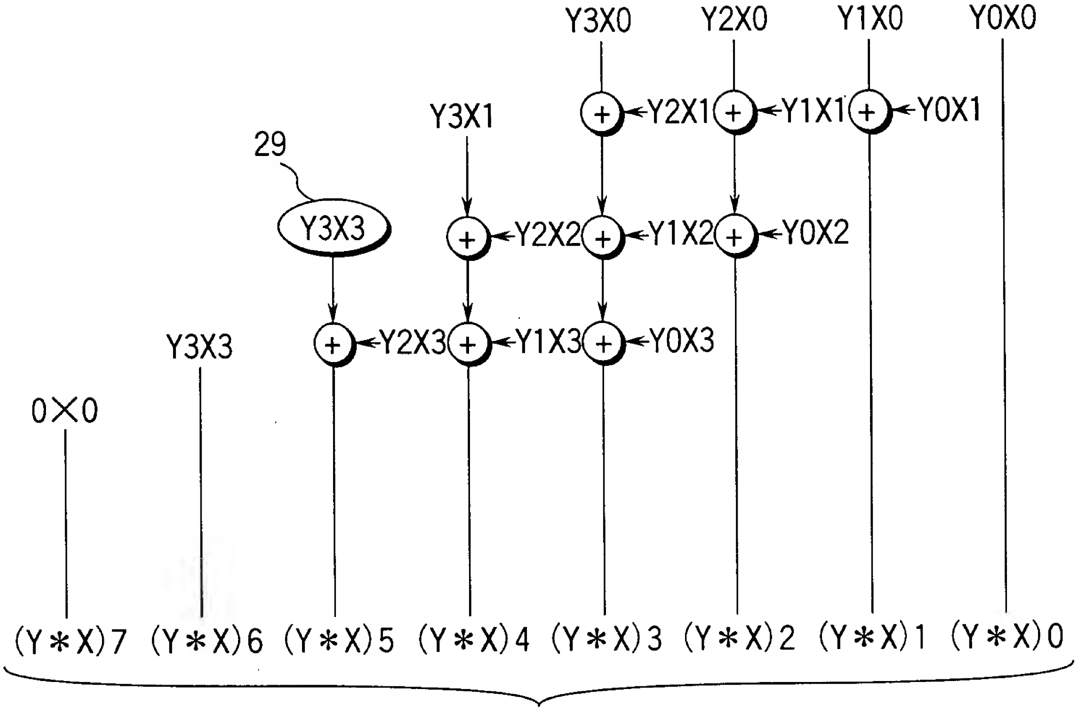


FIG. 2A

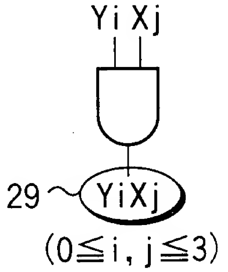


FIG. 2B

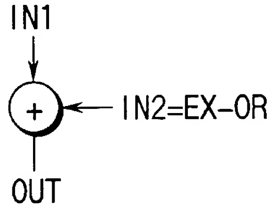


FIG. 2C

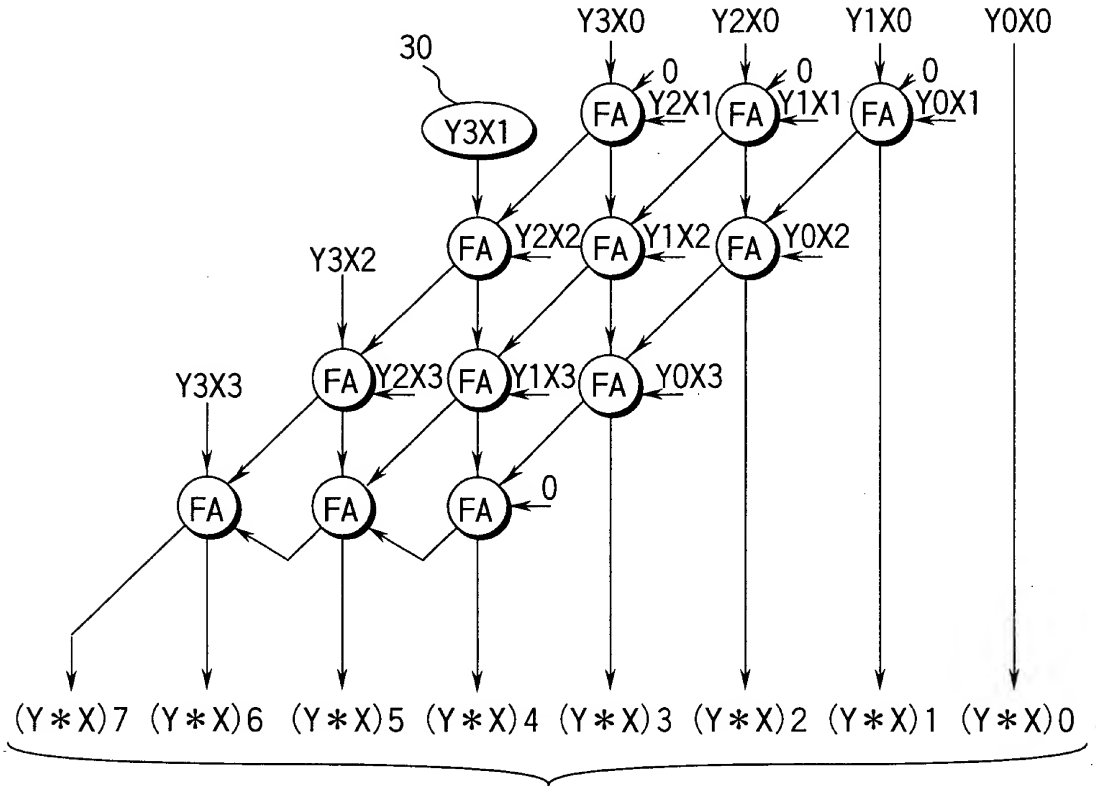


FIG. 3A

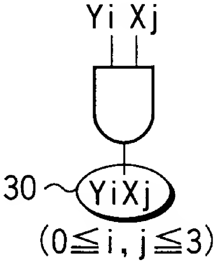


FIG. 3B

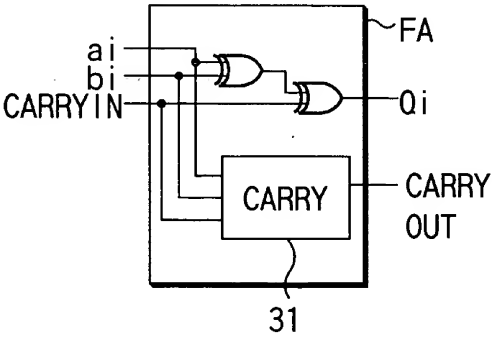


FIG. 3C

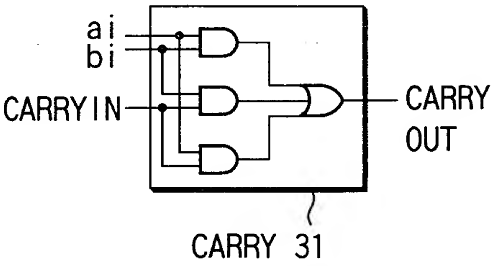


FIG. 3D

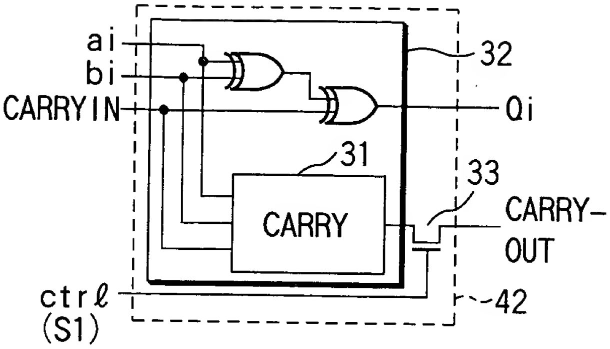
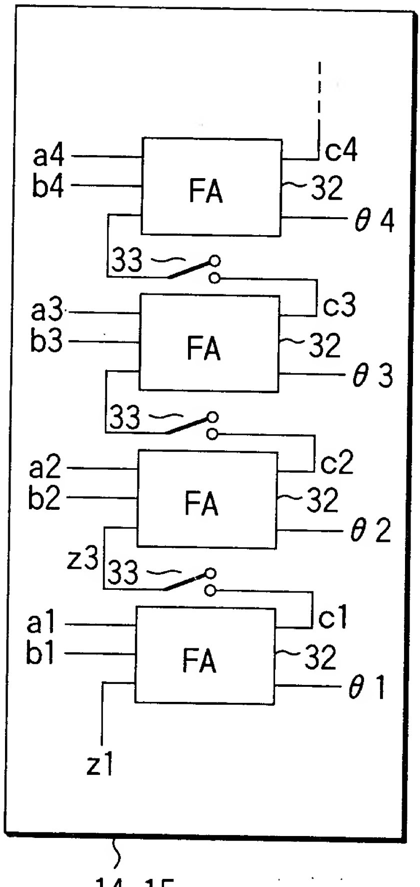


FIG. 5



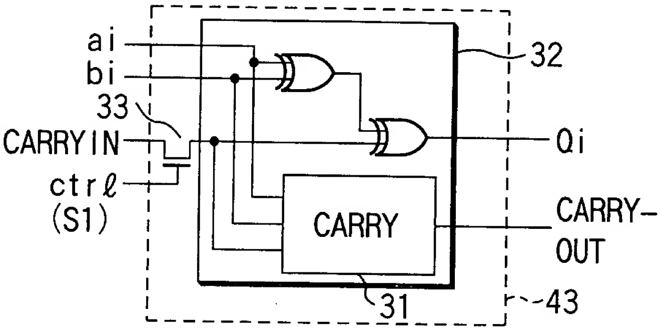


FIG. 6

FIG. 4

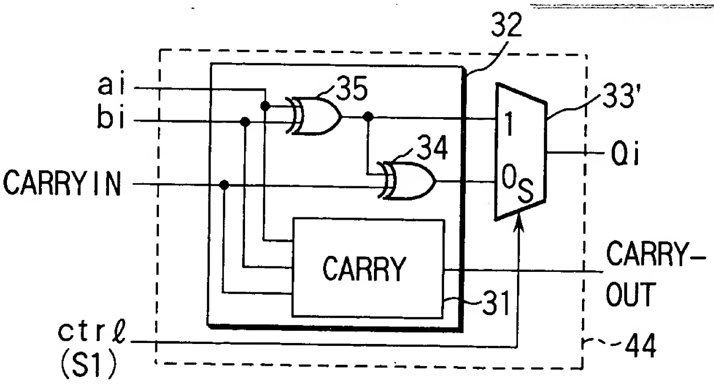


FIG. 7

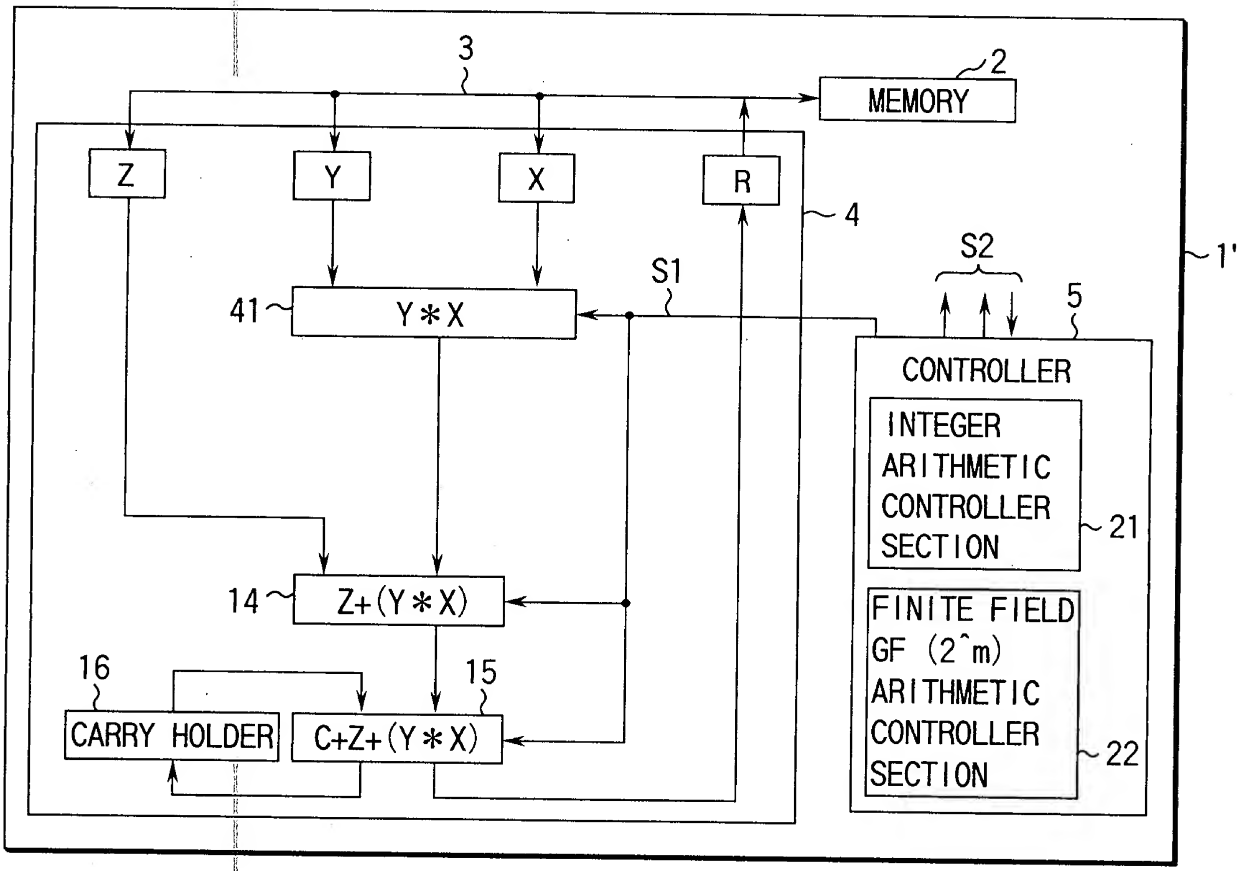

3
2
MEMORY
Z
Y
X
R
4
1'
S2
5
S1
41
Y＊X
CONTROLLER
INTEGER
ARITHMETIC
CONTROLLER
SECTION
21
FINITE FIELD
GF (2^m)
ARITHMETIC
CONTROLLER
SECTION
22
14
Z+(Y＊X)
16
15
CARRY HOLDER
C+Z+(Y＊X)

FIG.8

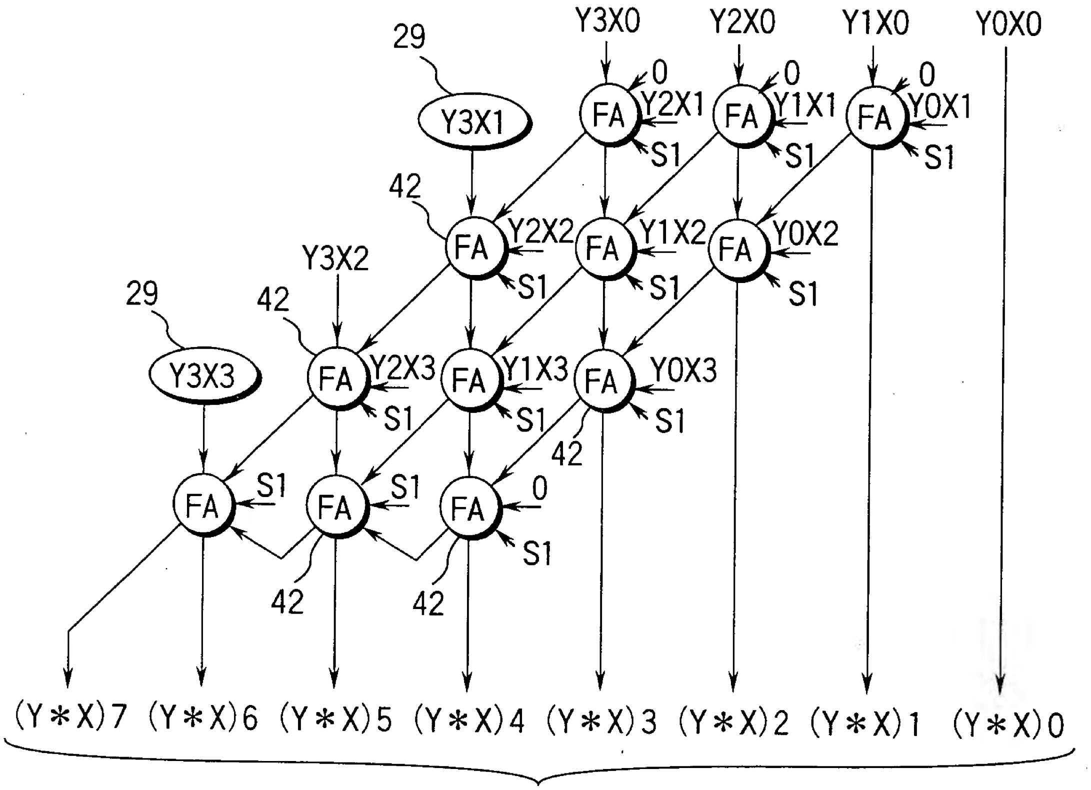

Y3X0
Y2X0
Y1X0
Y0X0
29
Y3X1
0
Y2X1
S1
0
Y1X1
S1
0
Y0X1
S1
FA
42
Y2X2
S1
Y1X2
S1
Y0X2
S1
Y3X2
29
Y3X3
42
Y2X3
S1
Y1X3
S1
Y0X3
S1
42
S1
S1
0
S1
42
42
(Y∗X)7
(Y∗X)6
(Y∗X)5
(Y∗X)4
(Y∗X)3
(Y∗X)2
(Y∗X)1
(Y∗X)0

FIG. 9A

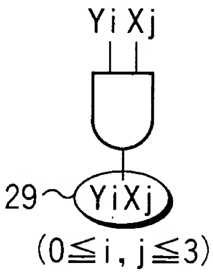

Yi Xj
29
YiXj
(0≦i, j≦3)

FIG. 9B

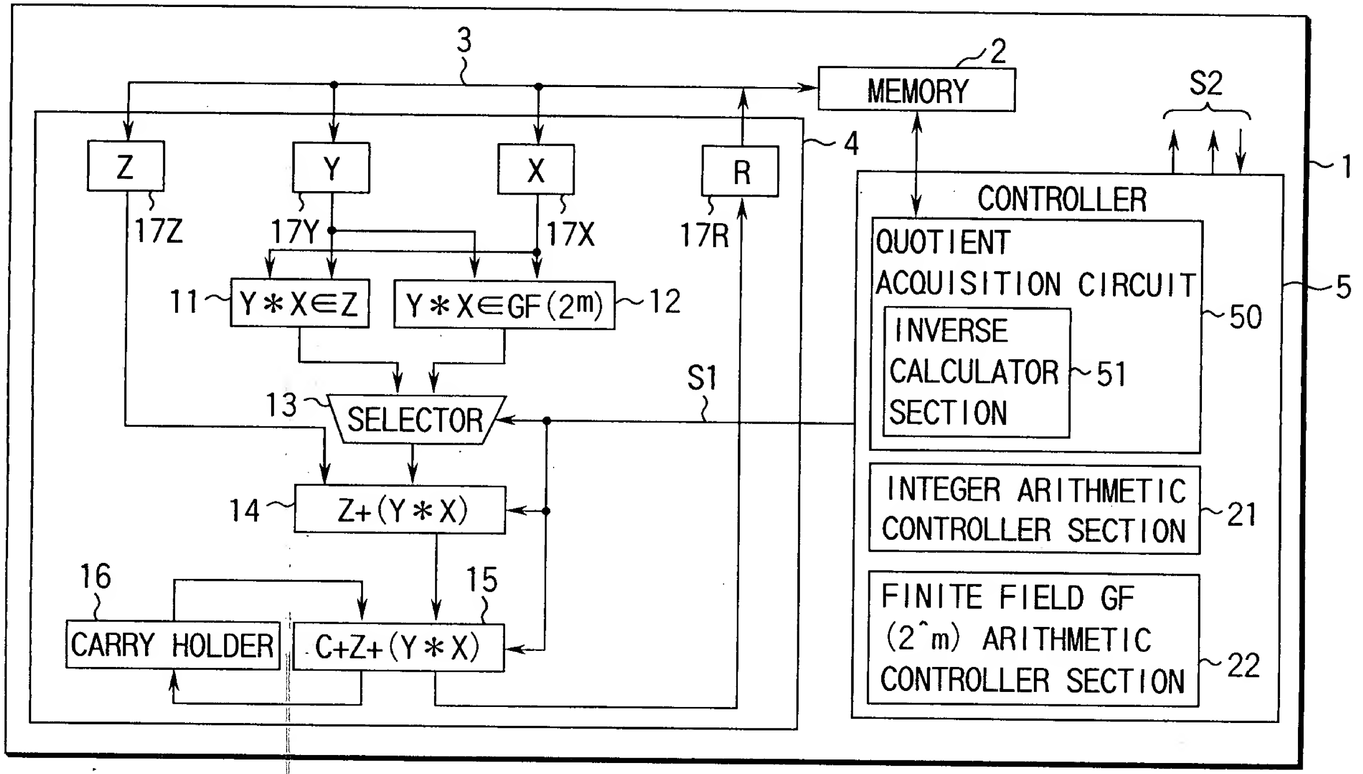

3
2
MEMORY
S2
Z
Y
X
R
4
1
17Z
17Y
17X
17R
CONTROLLER
QUOTIENT ACQUISITION CIRCUIT
INVERSE CALCULATOR SECTION
5
50
51
11
Y∗X∈Z
Y∗X∈GF(2m)
12
S1
13
SELECTOR
14
Z+(Y∗X)
INTEGER ARITHMETIC CONTROLLER SECTION
21
16
15
CARRY HOLDER
C+Z+(Y∗X)
FINITE FIELD GF (2^m) ARITHMETIC CONTROLLER SECTION
22

FIG. 10

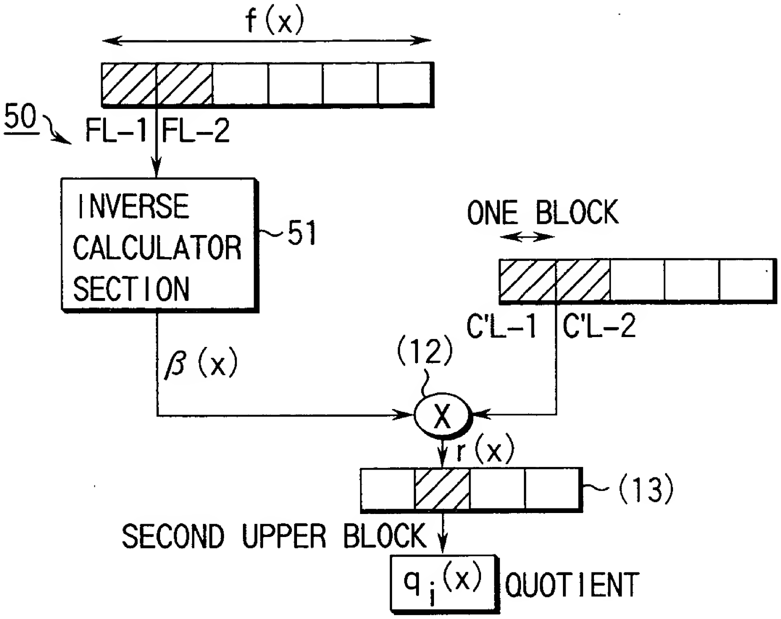

f (x)
50
FL–1
FL–2
INVERSE CALCULATOR SECTION
51
ONE BLOCK
C'L–1
C'L–2
β (x)
(12)
X
r (x)
(13)
SECOND UPPER BLOCK
$q_i(x)$
QUOTIENT

FIG. 11

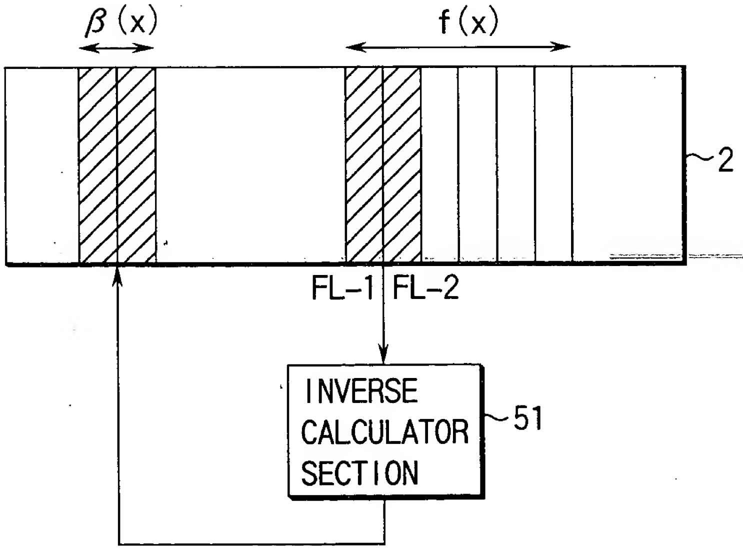

β (x)
f (x)
2
FL–1
FL–2
INVERSE CALCULATOR SECTION
51

FIG. 12

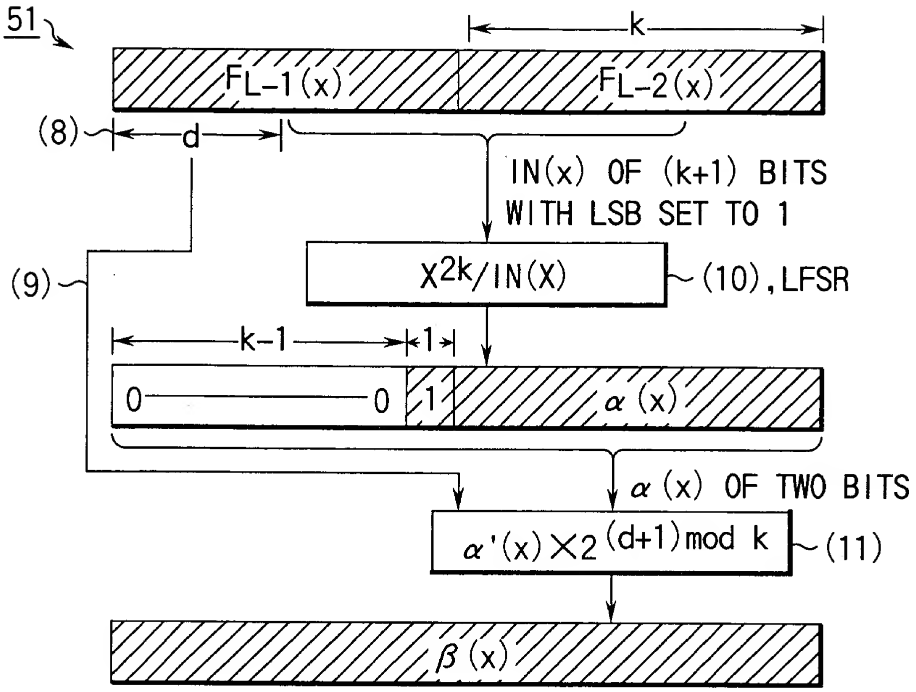

51
k
FL-1(x)
FL-2(x)
(8)
d
IN(x) OF (k+1) BITS
WITH LSB SET TO 1
(9)
X2k/IN(X)
(10),LFSR
k-1
1
0
0
1
α (x)
α (x) OF TWO BITS
α'(x)×2 (d+1)mod k
(11)
β (x)

FIG. 13

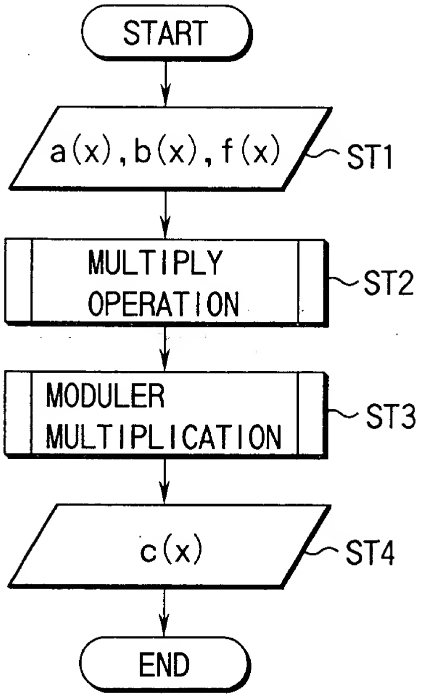

START
a(x),b(x),f(x)
ST1
MULTIPLY OPERATION
ST2
MODULER MULTIPLICATION
ST3
c(x)
ST4
END

FIG. 14

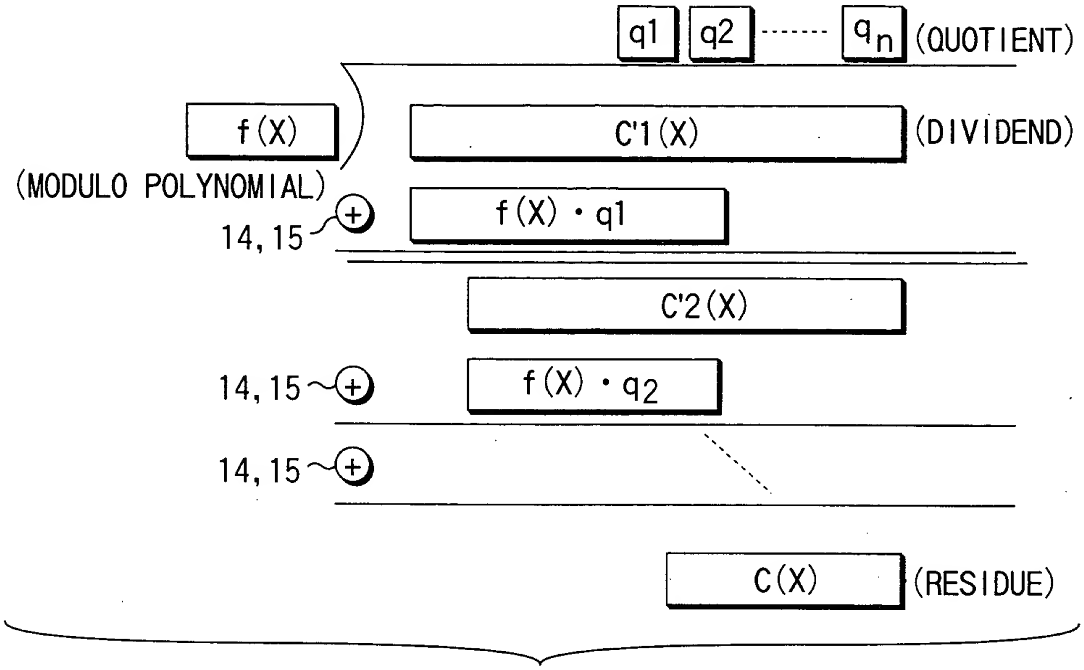

q1
q2
qn
(QUOTIENT)
f(X)
C'1(X)
(DIVIDEND)
(MODULO POLYNOMIAL)
14, 15
f(X) · q1
C'2(X)
14, 15
f(X) · q2
14, 15
C(X)
(RESIDUE)

FIG. 15

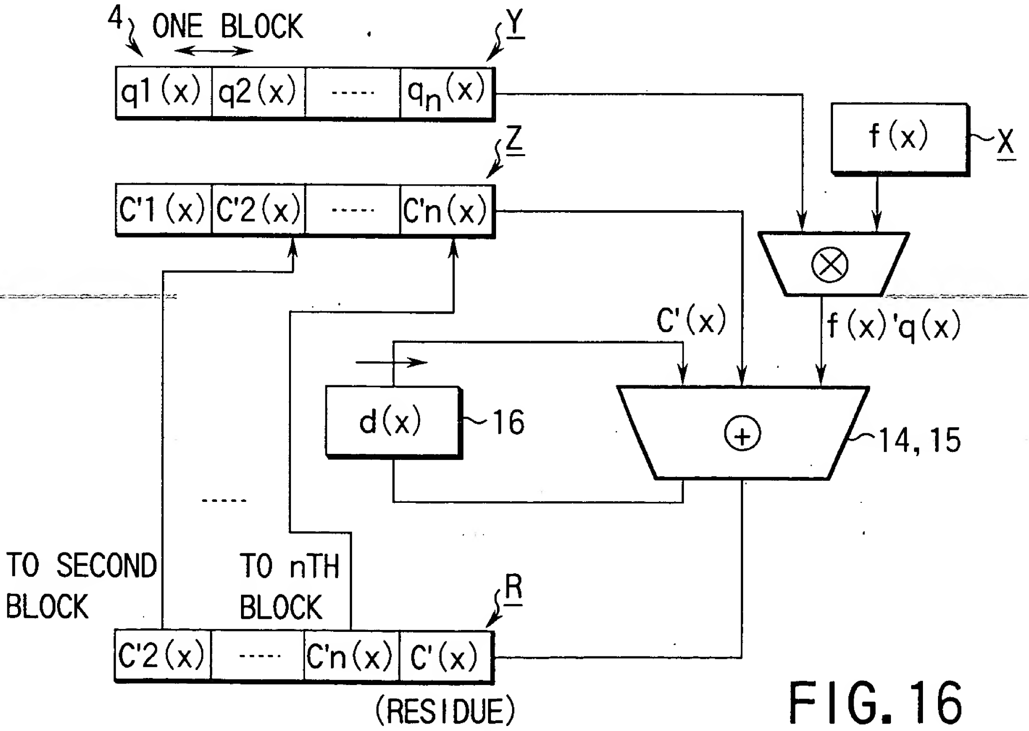

4
ONE BLOCK
Y
q1(x)
q2(x)
qn(x)
f(x)
X
Z
C'1(x)
C'2(x)
C'n(x)
C'(x)
f(x)'q(x)
d(x)
16
14, 15
TO SECOND BLOCK
TO nTH BLOCK
R
C'2(x)
C'n(x)
C'(x)
(RESIDUE)

FIG. 16

REQUIRED NUMBER OF CLOCKS FOR COMMAND

COMMAND		m=160	m=1024
ADDITION		14	68
MULTIPLY		64	2,116
SQUARE		25	133
DIVIDE	PRE-CALCULATION	35	35
	MAIN BODY	134	2,564

FIG. 17

REQUIRED NUMBER OF CLOCKS FOR GF(2^{160})

ARITHMETIC OPERATION	NUMBER OF CLOCKS	SR RATIO
ADDITION	14	ABOUT 4.6 TIMES
MULTIPLY	198	ABOUT 1.2 TIMES
SQUARE	159	ABOUT 1 TIMES

(SR RATIO)=(NUMBER OF CLOCKS)/
(NUMBER OF CLOCKS IN SHIFT REGISTER CIRCUIT)

FIG. 18

CIRCUIT SIZE (NUMBER OF GATES) OF COPROCESSOR

ARITHMETIC UNIT	8k
CONTROLLER	12.8k
RAM	8.5k
I/F	0.5k
WHOLE	ABOUT 30k

FIG. 19

ADDITIONAL CIRCUIT SIZE (NUMBER OF GATES)
FOR INTEGER BASED COPROCESSOR

ARITHMETIC UNIT	1k
CONTROLLER	3.8k
RAM	0(SHARED)
I/F	0(SHARED)
WHOLE	4.8k

FIG. 20

INDEPENDENT CIRCUIT SIZE (NUMBER OF GATES) OF GF (2^m)

	m=160	m=1024
ARITHMETIC UNIT	3.1k	3.1k
CONTROLLER	3.8k	3.8k
RAM	2.3k	8.5k
I/F	0.5k	0.5k
WHOLE	ABOUT 10k	ABOUT 16k

FIG. 21

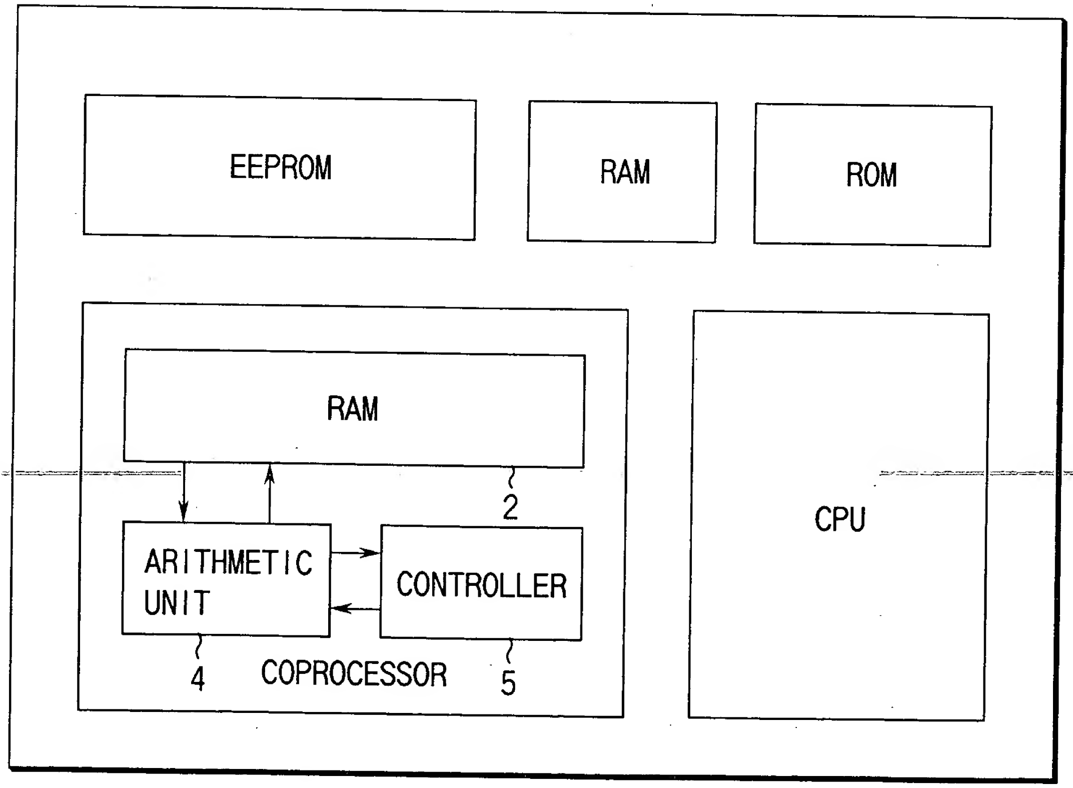


FIG. 23

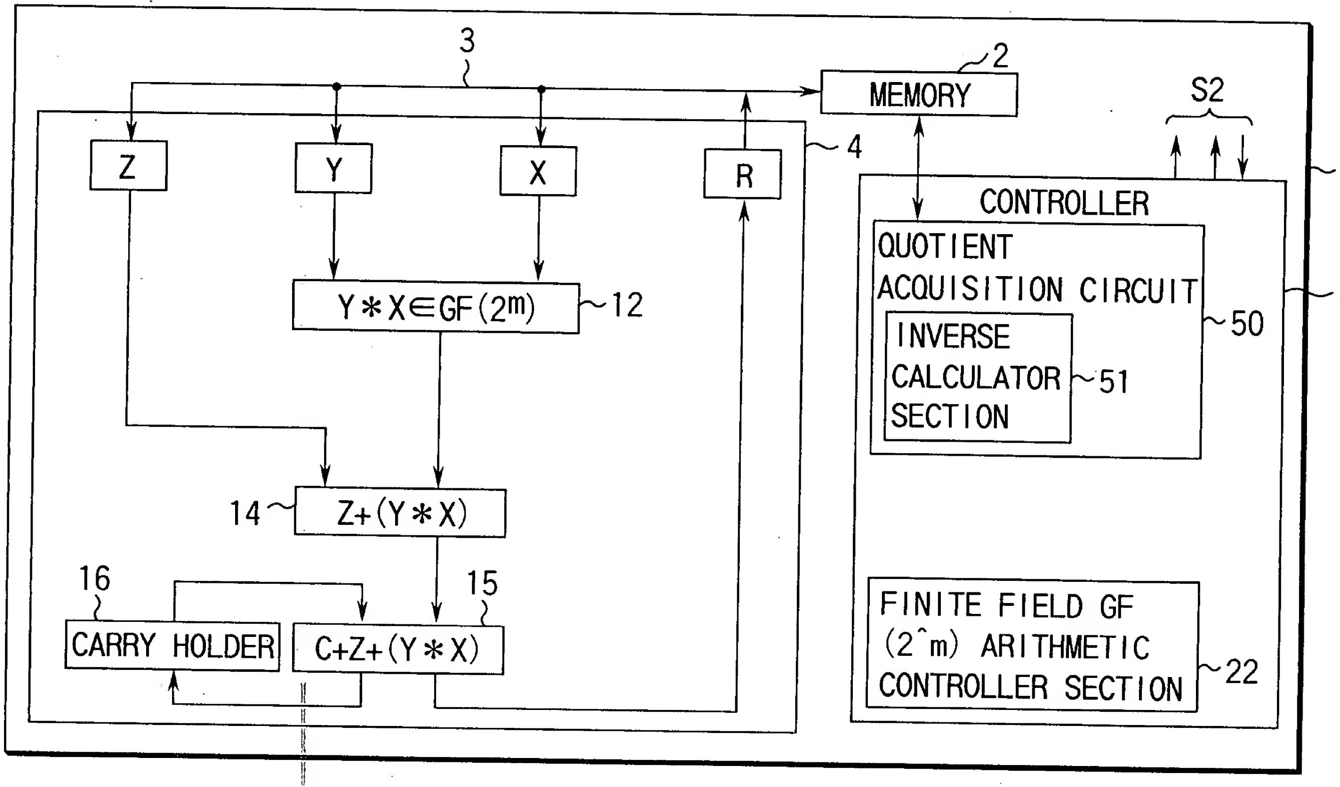

3
2
MEMORY
S2
4
1'
Z
Y
X
R
CONTROLLER
QUOTIENT ACQUISITION CIRCUIT
50
5"
INVERSE CALCULATOR SECTION
51
Y∗X∈GF(2m)
12
14
Z+(Y∗X)
16
15
CARRY HOLDER
C+Z+(Y∗X)
FINITE FIELD GF (2^m) ARITHMETIC CONTROLLER SECTION
22

FIG. 22

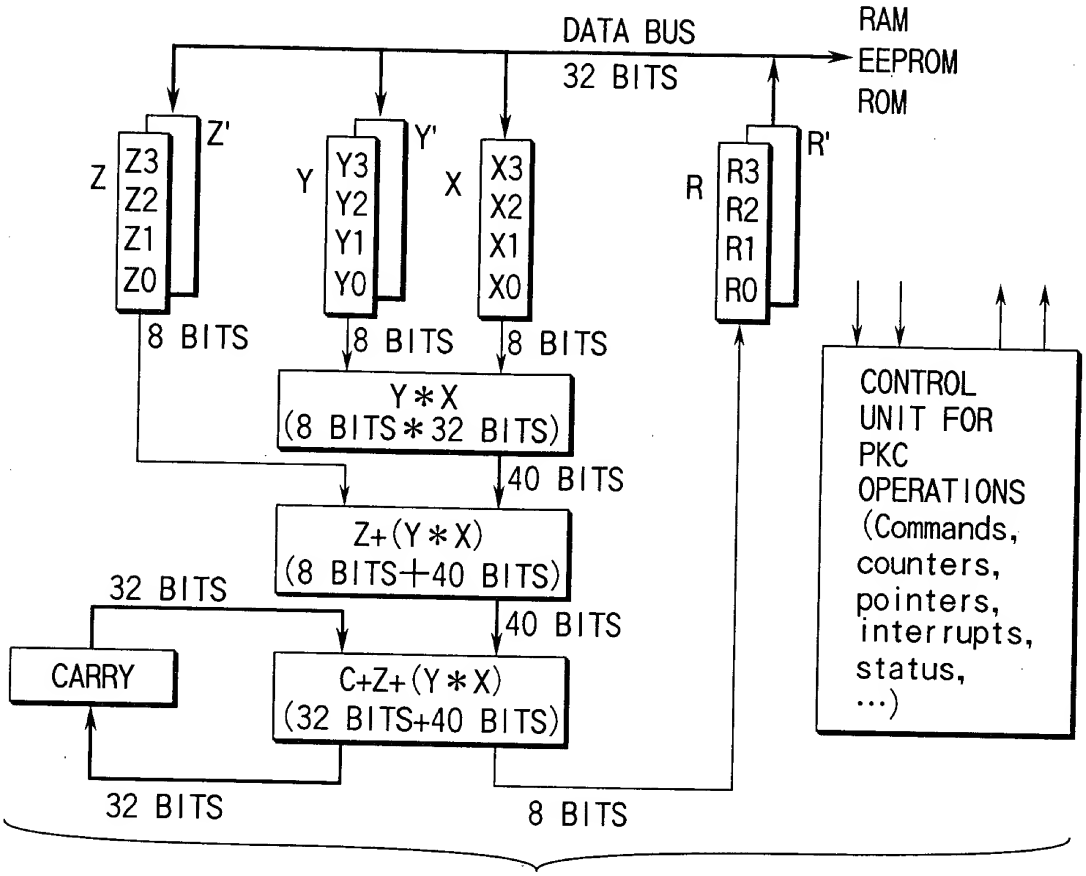

DATA BUS
32 BITS
RAM
EEPROM
ROM
Z
Z'
Z3
Z2
Z1
Z0
Y
Y'
Y3
Y2
Y1
Y0
X
X3
X2
X1
X0
R
R'
R3
R2
R1
R0
8 BITS
8 BITS
8 BITS
Y∗X
(8 BITS∗32 BITS)
40 BITS
Z+(Y∗X)
(8 BITS+40 BITS)
32 BITS
40 BITS
CARRY
C+Z+(Y∗X)
(32 BITS+40 BITS)
32 BITS
8 BITS
CONTROL
UNIT FOR
PKC
OPERATIONS
(Commands,
counters,
pointers,
interrupts,
status,
...)

FIG. 24

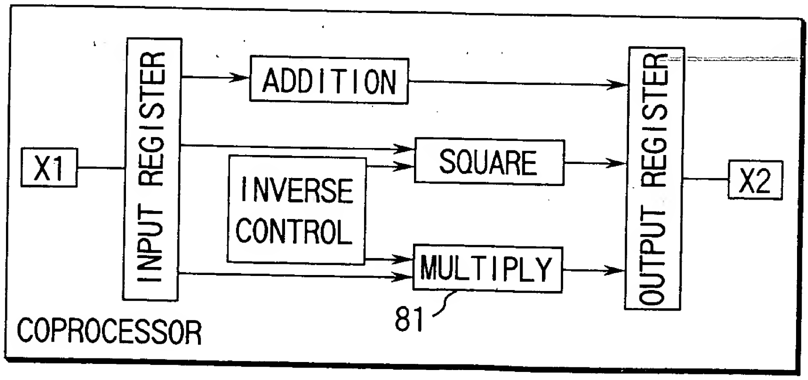

X1
INPUT REGISTER
ADDITION
SQUARE
INVERSE
CONTROL
MULTIPLY
81
OUTPUT REGISTER
X2
COPROCESSOR

FIG. 25

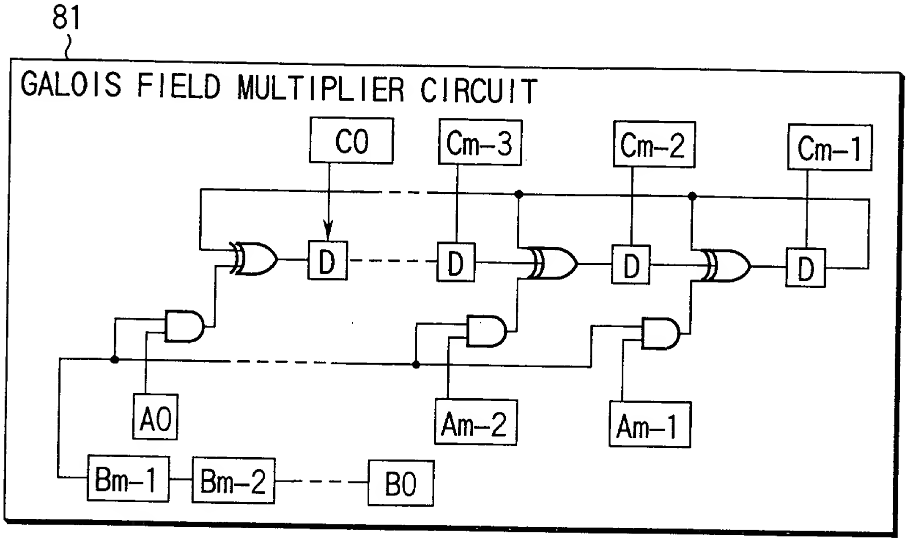

81
GALOIS FIELD MULTIPLIER CIRCUIT
C0
Cm–3
Cm–2
Cm–1
D
D
D
D
A0
Am–2
Am–1
Bm–1
Bm–2
B0

FIG. 26

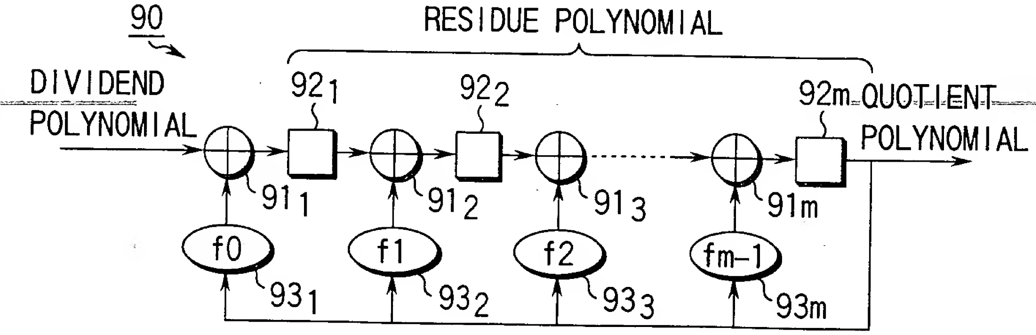

90
RESIDUE POLYNOMIAL
DIVIDEND POLYNOMIAL
92_1
92_2
92m
QUOTIENT POLYNOMIAL
91_1
91_2
91_3
91m
f0
f1
f2
fm–1
93_1
93_2
93_3
93m

FIG. 27